MAIL ROOM
NOV
9
1994
38
PAT. & TRADEMARK OFF.

"EXPRESS MAIL" MAILING LABEL NUMBER TB636169490US
DATE OF DEPOSIT:
I HEREBY CERTIFY THAT THIS PAPER OR FEE IS BEING DEPOSITED WITH THE UNITED STATES POSTAL SERVICE "EXPRESS MAIL POST OFFICE TO ADDRESSEE" SERVICE UNDER 37 cfr 1.10 ON THE DATE INDICATED ABOVE AND IS ADDRESSED TO THE COMMISSIONER OF PATENTS AND TRADEMARKS, WASHINGTON, D.C. 20231.

FRANK J. CATALANO
TYPED OR PRINTED NAME OF PERSON MAILING

SIGNATURE OF PERSON MAILING PAPER OR FEE.

UNITED STATES PATENT APPLICATION

FOR

DYNAMIC INFEED CONTROL FOR SEGMENTING SWARF IN A LATHE APPLICATION

DYNAMIC INFEED CONTROL FOR SEGMENTING SWARF IN A LATHE APPLICATION

BACKGROUND OF THE INVENTION:

This invention relates generally to lathe machines and more particularly concerns the swarf accumulated during the lathe shaping of certain metals and plastics.

In the lathe shaping of wood and also of plastics based in thermoset resins, the resulting swarf generally consists of fine particles or powder. Swarf in this form is readily collected by vacuum into a relatively high density mass suitable for storage and transport. However, in the lathe shaping of metals and of plastics based in thermoplastic resins, the swarf is accumulated in long, continuous, curled or spiraled strands.

For example, one such plastic is the shock resistant, virtually indestructible polycarbonate used in safety lenses, children's spectacle lenses and the like. In the lathe shaping of such lenses, the resulting polycarbonate strand makes swarf removal difficult because it easily tangles and snags, interrupting flow of the swarf along the vacuum path and backing the swarf up into the lens generating equipment. It also adversely affects the surface finish of the lens as the swarf collects around the cutting tool. Similar problems are experienced in other lathe applications.

In the spectacle lens industry, present solutions to the swarf strand problem include chipping, melting and constant vigilance approaches. In the chipping approach auxiliary equipment in the vacuum path breaks or mulches the swarf strand into small segments that are more easily manageable. Such equipment is costly, extremely noisy and readily subject to failure as broken swarf frequently finds its way into the equipment's bearings. The melting approach, while technically feasible, is unfortunately impractical

2

as further auxiliary equipment is required to collect the swarf and bring the swarf to melting temperatures. The resulting solidified mass presents a new set of management problems all its own. The constant vigilance approach requires the continuing presence of supervisory personnel to interrupt operation of the lathe, remove the swarf and restart the lathing process every time tangling, snagging or undesirable collection of swarf occurs. The result is frequent and lengthy down time. Even after the lathe is cleared of this swarf, the swarf still remains in its unmanageable long strand condition.

It is, therefore, an object of this invention to provide a swarf control which causes swarf produced by a lathe to be segregated into manageable lengths. A further object of this invention is to provide a swarf control which causes swarf to be segmented by the lathe itself rather than by auxiliary equipment not otherwise needed in the lathing process.

3

SUMMARY OF THE INVENTION:

In accordance with the invention, a dynamic infeed control is used to segment swarf produced in a lathing operation into short manageable segments.

The preferred dynamic method for segmenting the swarf is to add a sine wave motion to the nominal infeed motion. The amplitude of the sine wave is 0.5 times the nominal infeed, although this may vary somewhat due to the properties of the specific material being machined. The frequency of the sine wave is a non-zero integral multiple of the rotational frequency of the lens plus 0.5. Thus the minimum sine wave frequency will be 1.5 times the rotational frequency of the lens and this factor may increase by increments of 1. In equation form, $W_{SW} = (n + 0.5) \times W_{RL}$ where W_{SW} is the frequency of the sine wave, W_{RL} is the rotational frequency of the lens and n is an integer equal to or greater than 1.

Application of this principle creates relative minima and maxima during one lens rotation that correspond to the relative maxima and minima on the next lens rotation, respectively. This causes the width of the strand of swarf to cycle in a range between approximately twice the nominal infeed and zero. Reducing the width of the strand to zero results in segmenting or breaking the strand of swarf. Because it may not be necessary to fully reduce the width of the strand to zero to break it, the amplitude of the sine wave may be relaxed somewhat depending on the material in question. Alternatively, the amplitude may be increased to introduce or increase deformation effects on the swarf which are beneficial to swarf containment.

The frequency relationship stated above insures that the relative minima of one

4

revolution will occur at precisely the same angle as the relative maxima on the next revolution. Likewise, it insures that the relative maxima of one revolution will occur at precisely the same angle as the relative minima of the next revolution.

By applying the dynamic infeed control to the lathe, a smoother finished surface is obtained, the swarf is broken up at the lens or work piece, only segmented swarf is introduced into the suction system, no auxiliary chipping or melting equipment is required and down time and operator involvement is minimized.

BRIEF DESCRIPTION OF THE DRAWINGS:

Other objects and advantages of the invention will become apparent upon reading the following detailed description and upon reference to the drawings in which:

FIGURE 1 is a block diagram illustrating a lens generator having a static infeed control;

FIGURE 2 is a front elevation view of a lens illustrating the spiral lathing path resulting from use of a lens generator having a static infeed control of the prior art;

FIGURE 3 is an enlarged front elevation view of a lens illustrating a preferred sinusoidal spiral lathing path resulting from use of a lens generator having the dynamic infeed control of the present invention;

FIGURE 4 is a graphic illustration of a sinusoidal spiral lathing path in which the frequency of the sinusoidal component 1.5 times the rotational frequency of the lens; and

FIGURE 5 is a block diagram illustrating a lens generator having the dynamic infeed control of the present invention.

While the invention will be described in connection with a preferred embodiment, it will be understood that it is not intended to limit the invention to that embodiment. On the contrary, it is intended to cover all alternatives, modifications and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

6

DETAILED DESCRIPTION OF THE INVENTION:

To understand the principles of the present invention, it is helpful to summarize the principles of the prior art. As shown in Figure 1, one presently known lens generator would include a lens or workpiece system **10** and a blade or tool system **30** under the control of a computer **40**. An auxiliary system **50** removes the swarf from the device. Typically, the lens system **10** includes a carriage and drive motor **11** having its shaft **13** connected to a workpiece such as a lens **15**. The lens carriage **11** is mounted on tracks **17** for reciprocal motion along a Y axis **19**. The shaft **13** rotates about an X axis **21** perpendicular to the Y axis **19**, the angular rotation of the shaft **13** in relation to a zero reference being identified as an angle θ **23**. The blade or tool system **30** includes a carriage **31** on which a tool such as a blade **33**, diamond cutter or other known cutting device is mounted. The blade or tool carriage **31** is mounted on tracks **35** which permit reciprocal motion of the blade carriage **31** along an X axis **37**. Under the control of the computer **40**, the positions of the carriages **11** and **31** and the angular position θ of the shaft **13** are coordinated to lens data defining the desired curvature of the lens **15** so that, as the lens **15** moves along the Y axis **19** from the outer edge of the lens **15** to the center of the lens **15**, the X axis penetration of the blade **33** is varied to properly contour the lens **15**. Typically, the computer system **40** will include linear encoders having perhaps a 1 micron resolution for determining the position of the carriages **11** and **31** along their Y **19** and X **37** axes, respectively, and a rotary encoder having perhaps a 0.04 degree angular resolution about the shaft X axis **21**.

In the operation of the prior art lens generator, as can best be seen in Figure 2,

7

as the lens **15** rotates about the shaft X axis **21** and the lens **15** gradually traverses along the Y axis **19**, the blade **33** removes material from the lens **15** along a static spiral path **25** from the outer edge of the lens **15** to the center of the lens **15** at the shaft X axis **21**. The result is that the material removed in the lathing process consists of a continuous strand of the curled and spiraled material removed from the edge to the center of the lens **15**. To remove this strand of material or swarf from the lens maker, the auxiliary system **50** draws the swarf along a collection path **51** extending from the leading end of a vacuum hose **53** proximate the lathing point where the blade **33** meets the lens **15** through a chipping device **55** by a vacuum **57** so as to collect the chipped swarf **59** in the container of the vacuum **57**. If no chipping device **55** or other auxiliary means for segmenting or consolidating the swarf **59** is used, then the swarf readily entangles in the auxiliary system **50** or in the components of the lens generator. Even when such auxiliary devices are used, entanglement still may occur before the swarf reaches those devices. Wherever entanglement occurs, the swarf **59** quickly backs up into the lathing mechanism with the results hereinbefore stated.

Turning to Figure 3, the solution to the problem is to superimpose on the static spiral path **25** a dynamically reciprocating path **27**. That is, while the lens **15** shifts along the Y axis **19** at a substantially constant rate so that the blade **33** passes from the outer edge of the lens **15** to the center of the lens **15**, the position of the lens **15** is also reciprocated at a selected frequency forwardly and rearwardly of the static spiral path **25**.

As shown in Figure 4, the static spiral path **25** or infeed path has an oscillatory component added to the nominal infeed. Preferably, a sine wave motion is added to the

8

nominal infeed motion. The amplitude of the sine wave is 0.5 times the nominal infeed, although this may vary somewhat due to the properties of the specific material being machined. The frequency of the sine wave is a non-zero integral multiple of the rotational frequency of the lens plus 0.5. Thus the minimum sine wave frequency will be 1.5 times the rotational frequency of the lens and this factor may increase by increments of 1. In equation form, $W_{SW} = (n + 0.5) \times W_{RL}$ where W_{SW} is the frequency of the sine wave, W_{RL} is the rotational frequency of the lens and n is an integer equal to or greater than 1. The oscillatory component is given by $C_{SW} = 1/2\ \mathrm{I} \times \mathrm{Sin}\ [\theta \times (N + 0.5)]$ where C_{SW} is the sine-wave component, I is the nominal-infeed, θ is the rotational angle and N is any integer greater than or equal to 1. In the illustration shown, N is equal to 1. It can be seen that on each successive rotation, the relative minima **71** occur at the same angle as the relative maxima **73** of the previous pass. This relationship causes the swarf to be segmented, the area **75** corresponding to one such segment. To produce shorter swarf segments, a larger value of N is used. As shown in Figure 4, the swarf width at the concurrence **77** of maxima and minima is substantially zero while the swarf width **79** at the divergence of maxima and minima is approximately twice the nominal infeed width **81**. The frequency relationship stated above insures that the relative minima of one revolution will occur at precisely the same angle as the relative maxima on the next revolution. Likewise, it insures that the relative maxima of one revolution will occur at precisely the same angle as the relative minima of the next revolution. To accomplish this segmenting of swarf, as can be seen in Figure 4, the rotational position of the lens **15** or workpiece angle θ **23** must be coordinated with the static movement and dynamic

print cap "I"

9

movement of the lens **15** along the Y axis **19** and the positioning of the blade **33** along the X axis **37**.

The amplitude of the sine wave may be relaxed somewhat depending on the material being lathed. On the other hand, the amplitude may be increased to introduce or increase deformation effects on the swarf which are beneficial to swarf containment or to compensate for material flexure during the lathing operation.

Other oscillatory motions besides a sine save may be used as long as the tool **33** leaves the workpiece **15** at sufficient intervals during the process. The use of a sine wave superimposed on the spiral infeed is beneficial for a servo system since there are no higher order harmonics to which the servo system must respond. However, other types of dynamic motions may be preferred in some specific instances. For instance, when machining a rotationally symmetric surface, it may be desirable to run the spindle at a very high rpm. Using a sine wave at the minimum of 1.5 times the rotational frequency might result in a dynamic infeed component of too high a frequency for the servo system. Furthermore, the vibration produced might be undesirable. To counter this effect, the nominal infeed can be reduced to zero and all of the infeed produced by dynamic infeed components. Typically in this case the infeed will be a constant velocity move or a parabolic move in which the tool feeds in and then stops. Then the workpiece is allowed to make a complete "cleanup" rotation. This causes the swarf to reach zero width by the time the "cleanup" rotation is complete, effectively breaking the swarf strand. The disadvantage of this method is that the swarf segments are longer than those produced with the sine wave method.

Turning now to Figure 5, a lens generator incorporating the principles of the

10

present invention is illustrated. The workpiece system **10** and tool system **30** are substantially the same as illustrated in Figure 1. In the computer system **90**, the zero reference encoder dividing the lens revolution into, for example, 4,000 counts, provides positional coordination of the angular position θ of the lens **15** with the X **37** and Y **19** axes encoders so that, under the control of the computer **90**, the maxima **73** and minima **71** substantially coincide for sequential rotations of the lens **15**. Thus, while the frequency of oscillation remains constant, the wave length of the oscillation is gradually reduced to approximately zero as the blade **33** approaches the shaft X axis **21**. As shown in Figure 5, given this dynamic infeed control lens generator, the auxiliary system **100** does not require the chipping device **55** shown in Figure 1 or any other segmenting equipment so that the collection path **101** includes only a vacuum hose **103** extending to a vacuum **105** for collecting the swarf **107**.

It will be obvious to those skilled in the art that, should it be desired to machine the edge of the lenses rather than the face of the lens, the oscillatory action could be applied along the X axis **37** rather than the Y axis **19** so as to segment the swarf derived from the edge of the lens **15**.

Thus, it is apparent that there has been provided, in accordance with the invention, a dynamic infeed control for segmenting swarf in a lathe application that fully satisfies the objects, aims and advantages set forth above. While the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art and in light of the foregoing description. Accordingly, it is intended to embrace all such alternatives, modifications and variations as fall within the spirit of the appended claims.

11